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(54) **Heat exchanger fin arrays.**

(57) Heat exchanger fin (12) arrays of uniform width are made and are subsequently divided lengthwise into arrays of smaller width. A pattern (11) of weaknesses is provided for facilitating lengthwise division. Before such division, the array may be attached to a uniform number of heat exchange elements (13) to form a heat exchanger sub-assembly of uniform size. Lengthwise division then produces smaller sub-assemblies. The invention allows flowline production of heat exchangers of a wide variety of different sizes and utilizing fin forming and welding apparatus at or near full capacity.

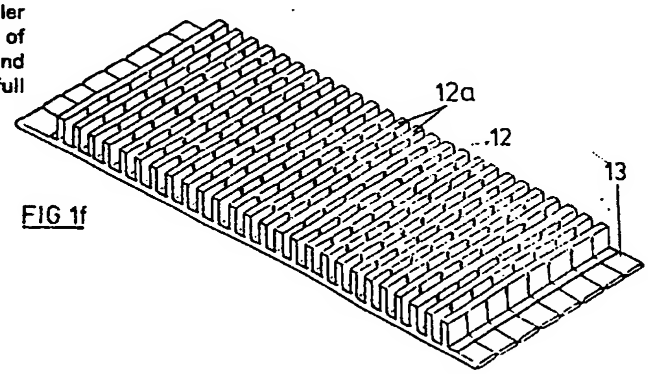

FIG 1f

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HEAT EXCHANGER FIN ARRAYS

The present invention relates to heat exchanger fin arrays, to methods of making such arrays, to heat exchange sub-assemblies including such arrays, to methods of making such sub-assemblies and to apparatus for carrying out the methods. By "fin" in this context is meant a heat conductive material for attachment to a heat exchanger, which material has a configuration intended to enhance heat transfer between the heat exchanger and the medium in which the heat exchanger is located by increasing the surface area across which heat transfer takes place.

The invention relates particularly, though not exclusively, to the fins on hot water central heating panel radiators which comprise tubes and fins disposed transversely to one another.

There is a market demand for a variety of different sizes of hot water central heating radiators provided with fin arrays; furthermore, there is a market demand for a variety of different sizes of fin array for any particular size of radiator.

In a known method of making the fin arrays, coils or strips of sheet metal of a variety of different widths are used. A coil or strip of a particular width is put in the fin-making apparatus, and the apparatus is then operated to produce a batch of fin arrays of that particular width. The coil or strip, if not completely

used up, is then removed. The fin-making apparatus is then reset, a new coil or strip of a different width is put in the apparatus, and a further batch of a different width is produced. Either the production of the fin arrays must coincide with that of the panels to which the arrays are to be attached or alternatively fin arrays and/or panels must be stored until required. Furthermore coils or strips of a variety of different widths must be obtained and stocked. To lessen this disadvantage, manufacturers have tended, in spite of market demand, to limit the range of different sizes of panel and fin array which they produce. Production of a variety of sizes also has the drawback that both the fin-making apparatus and the apparatus which attaches the fin arrays to the panels tend to be under utilized as they are often used to produce fin arrays and attach them to panels of a size less than that of which they are capable.

The invention provides a method of making heat exchanger fin arrays characterized in that arrays of one or a small number of uniform widths are made and are subsequently divided lengthwise into arrays of smaller width.

The method has the advantage that only one or a small number of widths of heat conductive material need be obtained and stocked and that the fin making apparatus and the fin array attachment apparatus may operate at or near full capacity.

Advantageously, the arrays are provided with a pattern of weaknesses or other physical alterations for facilitating lengthwise division.

Advantageously, the pattern is repeated across the width of the array for facilitating division into any one of a number of different widths.

Advantageously, the weaknesses include apertures each of which is capable of receiving a jaw of a cutting tool and capable of receiving a mounting bracket or mounting bracket engagement piece.

The invention also provides a heat exchanger fin array characterized in that the array is provided with a pattern of weaknesses or other physical alterations for facilitating division into smaller arrays.

The invention further provides a heat exchanger fin array characterized in that the array is made by lengthwise division of a larger fin array.

In another aspect the invention provides a method of making heat exchange sub-assemblies each including a fin array and at least one heat exchange element characterized in that the fin array is made by a method according to the invention and in that before lengthwise division of the array of uniform width it is attached to each one of a uniform number of heat exchange elements disposed parallel to the length of the array thereby to hold the elements in mutually fixed relationship.

The invention also provides a sub-assembly for use in making a heat exchanger comprising a plurality of heat exchange elements held in mutually fixed relationship by a fin array which is joined to each one of them characterized in that the fin array is provided with a pattern of weaknesses or other physical alterations parallel to the length of the heat exchange elements for facilitating division of the sub-assembly into smaller sub-assemblies.

The invention further provides a sub-assembly for use in making a heat exchanger comprising one or more heat exchange elements and a fin array joined to the or each heat exchange element characterized in that the sub-assembly is made from a sub-assembly comprising a plurality of heat exchange elements held in mutually fixed relationship by a fin array which is joined to each one of them, by division of the fin array parallel to the length of the heat exchange elements.

In another aspect the invention provides in combination, a heat exchanger including a fin array made by the method of the invention and one or more mounting brackets or mounting bracket engagement pieces projecting into one or more apertures of the array.

In a still further aspect the invention provides a method of making heat exchangers of a variety of desired different sizes characterized in that the method includes the steps of continuously making sub-assemblies according to the invention of one or a small number of uniform

widths and dividing or joining such sub-assemblies as necessary to provide sub-assemblies of the desired variety of desired different sizes.

The invention additionally provides apparatus for providing a pattern of weaknesses or other physical alterations on a length of sheet material for facilitating subsequent lengthwise division of the sheet material characterized in that the apparatus provides a pattern for facilitating division after the sheet material is subsequently formed into a heat exchanger fin array.

With the method of the invention it is possible, for example, for a manufacturer of finned central heating panel radiators, where the panel comprises flat tubes and fins disposed transversely to one another, to continuously produce a particular size of assembly such as, for example, eight flat tubes with connecting fins, and to subsequently divide the resulting assembly into smaller sizes, for example, six tubes and two tubes, by cutting the sheet metal in the region between two flat tubes, or, where a larger radiator (say ten tubes) is required, to add on extra tubes without or with fins.

The invention will now be described more particularly with reference to the accompanying drawings which illustrate, by way of example only, the manufacture and mounting of a finned hot water central heating panel radiator, where the panel comprises flat metal tubes.

In the drawings;

Figures 1a to 1h are views of a piece of sheet metal at successive stages of the radiator sub-assembly manufacturing process;

Figures 2a, 2b and 2c illustrate the preferred pattern of slits and slots on the fin array to facilitate lengthwise division;

Figures 3a, 3b and 3c illustrate successive stages in the division of a sub-assembly into smaller sub-assemblies;

Figures 4a and 4b to 4i are views similar to Figure 2c of the preferred slit and slot pattern and a series of alternative patterns respectively;

Figures 5a to 5g schematically illustrate a known method of, and apparatus for, producing fins at successive production stages;

Figures 6a to 6f schematically illustrate the invention and show the method of, and apparatus for, producing the pattern and fins at successive production stages;

Figures 7a and 7b are, respectively, sectional elevation and plan views of a detail of the radiator showing how it is mounted to a wall by means of a bracket on the wall and an engagement piece for engaging between the radiator fins and the bracket;

Figures 8a, 8b and 8c are, respectively, side elevation, front elevation and plan views of the engagement piece;

Figures 9a, 9b and 9c are, respectively, side elevation, front elevation, and plan views of the bracket;

Figure 10 is a front elevation of a piece of metal from which both the engagement piece and the bracket may be pressed; and

Figures 11a to 11d are similar to Figures 1d, 1e, 1f and 1g respectively but illustrate two variations of the method, according to one of which a sub-assembly with fin arrays on both sides is made and subsequently divided and according to the other of which the pattern is limited to that necessary for division, for aesthetic reasons or to reduce tool wear or for fin strength.

Reference will initially be made to Figures 1a to 1h. Figure 1a shows an effectively continuous strip of sheet metal 10 (Figure 1a). Figures 1b and 1c show intermediate and final stages in the provision of a pattern 11 of parallel slits and slots. The method of and apparatus for producing the slit and slot pattern 11 will be described in more detail below. Figure 1d shows an intermediate stage in the provision of an array of fins 12. Figure 1e shows a length of slotted finned sheet metal cut from the continuous strip. The method of and apparatus for producing the array of fins 12 will also be

described in more detail below. Figure 1f shows the length of slotted finned sheet metal attached by spot-welding to each one of a series of flat metal tubes 13. The spot-welding is carried out by passing the tubes 13 and the slotted finned sheet metal 10 through a multiple spot-welding machine. It will be appreciated from consideration of Figure 1f that the tubes 13 are held in their mutually parallel co-planar relationship only by the unslit portions 12a of the fins. The standard width radiator sub-assembly comprising tubes 13 and array of fins 12 may then be divided into the smaller sub-assemblies shown in Figures 1g. The division is achieved by cutting the previously unslit portions 12a of the fins 12. Thus a manufacturer can produce one standard width of radiator sub-assembly which can then be divided into any desired size. Cutting is done by means of a powered shears. Furthermore, as is shown in Figure 1h, an additional flat tube 13a without fins may be added to the sub-assembly where it is desired to produce a radiator in which it is not desired that the fin array should extend the full height of the radiator. Indeed a wide variety of different arrangements may be achieved with ease. For example larger radiator sub-assemblies of, say, twelve tubes may be made by simply joining two sub-assemblies of eight and four tubes. Unusual arrangements may be achieved if desired, such as for example panels in which

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the fins extend part way downwardly from the top of the radiator and part way upwardly from the bottom of the radiator but leave a gap in the middle for horizontally extending water connection pipes.

A variety of different radiators may thus be manufactured in a flowline in the following principal steps;

(a) uncoil sheet metal from a coil of sheet metal;

(b) form the pattern of slits and slots in the uncoiled sheet metal;

(c) form the fins

(d) cut to the different required lengths;

(e) introduce suitably arranged heat exchange tubes from a store of such tubes into the flowline and spot-weld each cut length to a number of tubes to form a radiator sub-assembly;

(f) if desired, divide the sub-assembly lengthwise into smaller sub-assemblies, which may sometimes be temporarily stored as required;

(g) if desired, introduce extra tubes or sub-assemblies from store into the flowline and add the extra tubes or sub-assemblies to sub-assemblies in the flowline; and

(h) introduce headers from a store into the flowline and add the headers to the sub-assemblies to form radiators.

Minor steps such as the provision of plural connections, additional strengthening welds, testing, painting and packaging have been omitted.

Step (f) will now be described in more detail. The proportions into which the uniform width sub-assemblies are divided are arranged so that insofar as possible the smaller sub-assemblies are used immediately in the flowline production. Where it is not possible to use the smaller sub-assemblies immediately, they are moved to temporary storage for use as soon as possible. If the smaller sub-assemblies are of a particular size which is not likely to be used in the near future, such as for example, sub-assemblies comprising just one or two tubes, these may be joined together to make larger sub-assemblies. These larger sub-assemblies may be used as one panel of a double panel radiator so that the joint line between the fin arrays is concealed between the two panels of the radiator.

To minimize the number of sub-assemblies of undesirable size being produced, such as for example sub-assemblies comprising just one tube, two different widths of coil may be used. Each radiator required to be produced during a particular period, for example a week,

may then be made from one or other width or by combining sub-assemblies obtained from the two different widths.

The flowline described above can be used to make radiators other than the single panel finned radiators described above. For example, double panel radiators may be made by joining two of the single panel radiators produced as described above. Unfinned radiators may also be made in the flowline by omitting most of the above described steps and just introducing the tubes and attaching the headers to them.

Similarly, fin arrays provided with a pattern of slots to facilitate subsequent division may also be used with panels other than those which comprise a series of unjoined elements. In such cases, lengthwise division of the fin arrays may be carried out before the fin arrays are attached to the panels.

Referring now to Figure 2, the preferred pattern 11 of slits and slots to be applied will now be described in more detail. Figure 2a shows the preferred pattern 11 which consists of an array of longitudinal cuts k, having at each end thereof cut-outs or apertures j. The dotted lines indicate where the sheet metal will be folded. Figure 2b is a detail of the finished radiator, illustrating how the pattern 11 in Figure 2a appears in the finished radiator. Figure 2c is a view taken along IIC-IIC of Figure 2b. The various dimensions of the fin

and slot patterns are represented in Figure 2a, 2b and 2c as "a", "b", "c", "d" and "f".

Referring now to Figure 3, there will now be described in more detail the division of a radiator sub-assembly consisting of heat exchange tubes 13 joined by a fin array having the preferred pattern 11 of slits and slots. Figure 3a is a view similar to 2c, showing a detail of the sub-assembly just before cutting. Cutting is done by means of a double-cutting powered hand-held shears (not shown) which removes (see Figure 3b) the bridging piece thereby dividing the assembly (Figure 3c). The shape of the cut-out j is intended to accommodate the cutting tool and also to eliminate sharp corners in the finished product.

Figure 4 (a) shows the presently preferred pattern 11 while Figures 4 (b) to 4 (i) show alternative patterns. In selecting a suitable pattern, various factors need to be taken into account, for example; the pattern should assist operation of the cutting tool; the pattern should not impede heat transfer from and within the fins and therefore the material removed should be as little as feasible and from as far away from the flat tubes as feasible; the pattern should not result in sharp corners in the finished product; the pattern should preferably not give an undesirable appearance to the finished product; and the pattern should not result in too great a reduction in the strength of the fins.

It should be noted that the pattern of slits and slots does not impede conductive heat transfer within the fins, as such heat transfer takes place from the base of the fins along the walls to the top of the fins and is parallel to the pattern.

Referring now to Figure 5, there is schematically illustrated a known method of making fins from a coil of sheet metal. The purpose of illustrating and describing the known method is to assist in understanding the method of the invention which will be described later. Figure 5a shows incoming sheet metal 10a from a coil which is not shown and outgoing finned metal 10b. An upper forming tool 52 moves vertically under the action of a power press and a lower forming tool 53 is stationary. Also shown are a metal feed 54, a pressure plate 55, a device 56 (shown as a spring in the Figure) for applying a controlled force to the pressure plate 55, and devices 57 which apply a controlled force to the pressure plate 55 near the end of the stroke considerably greater than the force applied by device 56. The devices 56 and 57 may, for example, comprise controlled hydraulic or pneumatic cylinders.

In Figure 5a, the metal feed 54 has just fed the sheet metal 10a into position and the upper forming tool 52 is about to descend. In Figure 5b the metal feeder 54 releases the sheet metal 10a and the upper forming tool 52

has descended to meet the sheet metal. In Figure 5c, the upper forming tool 52 continues to descend, causing the metal to wrap around the lower forming tool 53 drawing both the unformed and formed sheet metal towards the tool 53. The metal feed 54 returns to its home position. In Figure 5d, the upper forming tool 52 continues its descent, driving the pressure plate 55 ahead of it under relatively light pressure from device 56. At this point, devices 57 also come into play causing the sheet metal 10a to be gripped between the upper forming tool 52 and the pressure plate 55. In Figure 5e, the upper forming tool 52 descends just a little further causing the gripped metal 10a to be tightly wrapped around the corners of both the upper and lower forming tools 52, 53 and thus producing relatively well defined corners on the material. In Figure 5f, the upper forming tool 52 ascends and the pressure plate 55, under the action of device 56, follows the upper forming tool 52, pushing the formed fin 10b off the lower forming tool 53. The metal feed 54 closes to grip the metal. In Figure 5g, the upper forming tool 52 continues to the top of its stroke. The metal feed 54 moves the metal forward. The forming cycle has returned to the stage illustrated in Figure 5a. The cycle is automatically repeated, forming one fin for each press stroke.

Referring now to Figure 6, the method and apparatus of the invention will now be described. Some of the components are similar to those used in the known method described above and are designated by the same numerals. The additional components include stops 58 which limit the downward movement of the pressure plate 55 and devices 59 which apply a controlled force to the top tool to overcome the forces applied by devices 56 and 57 and also the natural resistance to bending of the sheet metal. A fixed lower block 60 contains the piercing and lancing dies for the pattern and a moveable upper block 61 supports the piercing punches 62 and lancing punches 63 and moves vertically together with the upper fin forming tool 52 under the action of the power press.

In Figure 6a the upper fin forming tool 52, piercing punches 62 and lancing punches 63 are about to descend. In Figure 6b the fins have been formed and the piercing punches 62 are about to make contact with the sheet metal. In Figure 6c the piercing punches 62 punch the sheet metal. In Figure 6d the lancing punches 63 come into contact with and part the sheet metal. In Figures 6c and 6d the stops 58 and devices 59 allow the upper fin forming tool 52 to remain stationary even though the press continues to descend. In Figure 6e the press returns to the top of its stroke. In Figure 6f further sheet metal is fed forward in readiness for the next stroke.

Alternatively, the pattern forming tool and the fin forming tool may be mounted in separate power presses. The sheet metal is then fed directly from thepattern forming tool and power press to the fin forming tool and power press using a pilot device to correctly locate the pattern in the fin forming tool.

Referring now to Figures 7, 8, 9 and 10, the radiator is mounted (see Figure 7) on a wall by means of an engagement piece 70 (illustrated in Figure 8) which engages firstly in the slots which were provided in the side walls of the fins to assist cutting, and secondly in a wall mounted bracket 71 (illustrated in Figure 9). The engagement piece 70 may slide horizontally relative to the bracket 71. The horizontal movement allows greater tolerance in the fitting of the brackets 71 to the walls and also allows for thermal expansion of the radiator. The mounting arrangement has a number of advantages. Firstly, it is not necessary to permanently attach any additional part or component to the radiator or to modify the radiator in any way to receive mounting hooks or brackets. Secondly, flexibility is offered in the choice of bracket location because there is an entire array of slots available. Thirdly, the mounting arrangement is at the back of the panel where it is concealed, which is aesthetically pleasing. Fourthly, the mounting arrangement is relatively inexpensive. Figure 10 shows

how the engagement piece 70 and bracket 71 may both be pressed from a single piece of metal. In an alternative arrangement, the engagement piece 70 could be supported by a floor mounted bracket.

Referring now to Figure 11, there are illustrated two variations of the method shown in Figure 1. The first variation comprises making a sub-assembly with fin arrays on both sides and subsequently dividing it into smaller sub-assemblies. The second variation comprises limiting the pattern to that necessary for division, such limitation may for examle be for aesthetic reasons or to reduce tool wear or to maintain fin strength. Figure 11a shows an intermediate stage in the production of one fin array from a length of sheet metal. A pattern of slits and slots has been provided to facilitate subsequent lengthwise division. The pattern comprises a single line of slits and slots. Fins have been formed along part of the continuous length. Figure 11c shows the fin array attached to flat tubes to form a sub-assembly and also shows a second fin array attached to the other side of the flat tubes. Figure 11d shows two sub-assemblies of smaller width obtained by lengthwise division of the sub-assembly of Figure 11c along the lines of slits and slots.

CLAIMS

1. A method of making heat exchanger fin (12) arrays characterized in that arrays of one or a small number of uniform widths are made and are subsequently divided lengthwise into arrays of smaller width.

2. A method according to Claim 1, characterized in that the arrays are provided with a pattern (11) of weaknesses or other physical alterations for facilitating lengthwise division.

3. A method according to Claim 2, characterized in that the pattern (11) is repeated across the width of the array for facilitating division into any one of a number of different widths.

4. A method according to Claim 2 or Claim 3 characterized in that the weaknesses include apertures (j) each of which is capable of receiving a jaw of a cutting tool and capable of receiving a mounting bracket (71) or mounting bracket engagement piece (70).

5. A heat exchanger fin array characterized in that the array is provided with a pattern (11) of weaknesses or other physical alterations for facilitating division into smaller arrays.

6. A heat exchanger fin (12) array characterized in that the array is made by lengthwise division of a larger fin (12) array.

7. A method of making heat exchange sub-assemblies each including a fin (12) array and at least one heat exchange element (13) characterized in that the fin (12) array is made by a method according to any of Claims 1 to 4 and in that before lengthwise division of the array of uniform width it is attached to each one of a uniform number of heat exchange elements (13) disposed parallel to the length of the array thereby to hold the elements (13) in mutually fixed relationship.

8. A sub-assembly for use in making a heat exchanger comprising a plurality of heat exchange elements (13) held in mutually fixed relationship by a fin (12) array which is joined to each one of them characterized in that the fin (12) array is provided with a pattern (11) of weaknesses or other physical alterations parallel to the length of the heat exchange elements (13) for facilitating division of the sub-assembly into smaller sub-assemblies.

9. A sub-assembly for use in making a heat exchanger comprising one or more heat exchange elements (13) and a fin (12) array joined to the or each heat exchange element (13) characterized in that the sub-assembly is made from a sub-assembly comprising a plurality of heat exchange elements (13) held in mutually fixed relationship by a fin (12) array which is joined to each one of them, by division of the fin (12) array parallel to the length of the heat exchange elements (13).

10. In combination, a heat exchanger including a fin (12) array made by the method of Claim 4 and one or more mounting brackets (71) or mounting bracket engagement pieces (70) projecting into one or more apertures of the array.

11. A method of making heat exchangers of a variety of different sizes characterized in that the method includes the steps of continuously making sub-assemblies according to Claim 8 of one or a small number of uniform widths and dividing or joining such sub-assemblies as necessary to provide sub-assemblies of the desired variety of desired different sizes.

12. Apparatus for providing a pattern (11) of weaknesses or other physical alterations on a length of sheet material (10) for facilitating subsequent lengthwise division of the sheet material (10) characterized in that the apparatus provides a pattern (11) of weaknesses or other physical alterations for facilitating division after the sheet material (10) is subsequently formed into a heat exchanger fin (12) array.

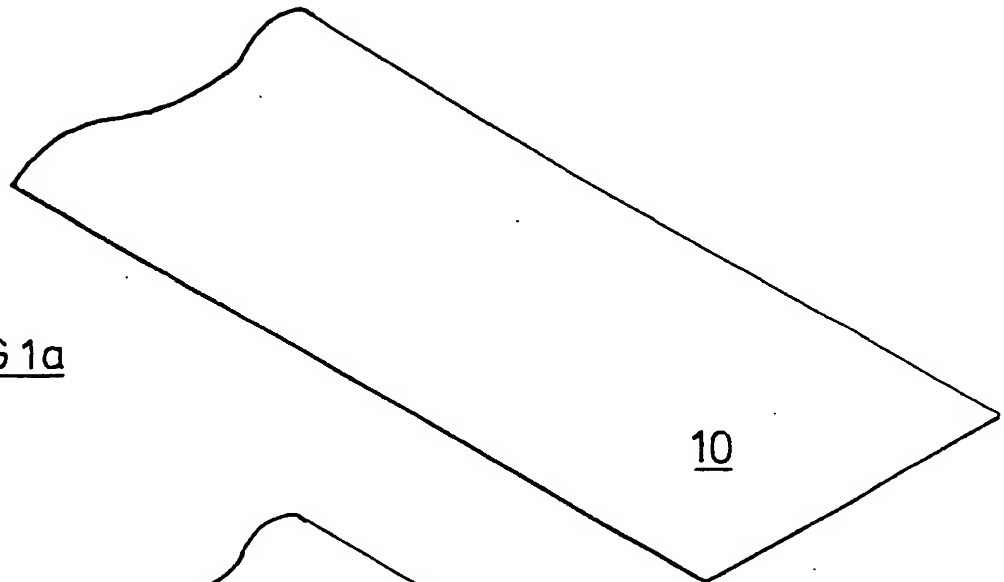


FIG 1a

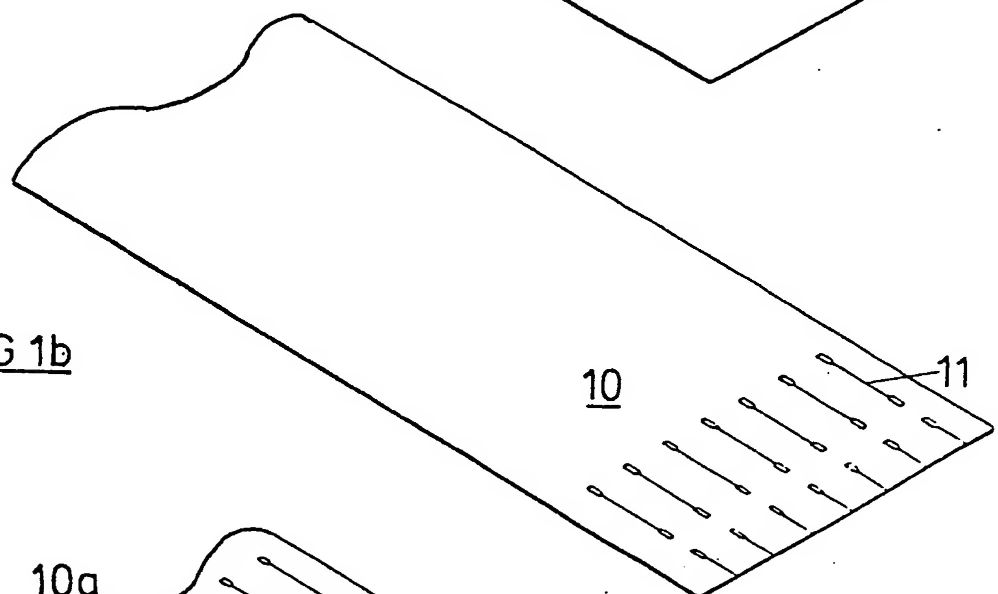
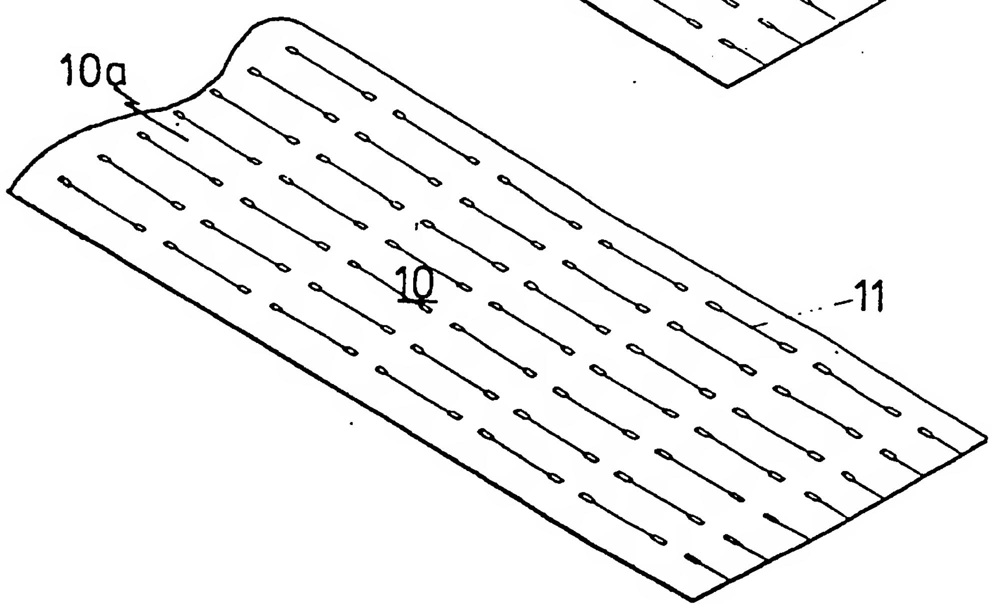


FIG 1b



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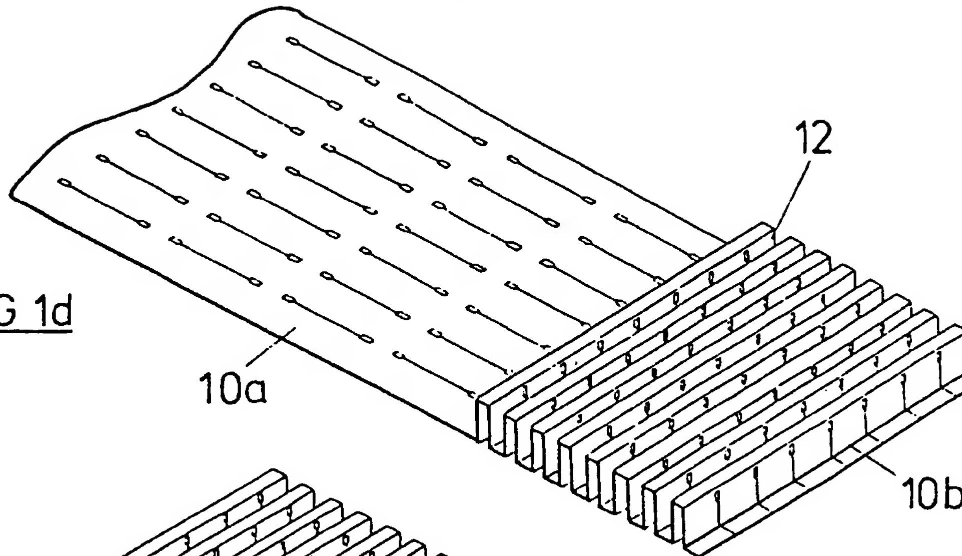


FIG 1d

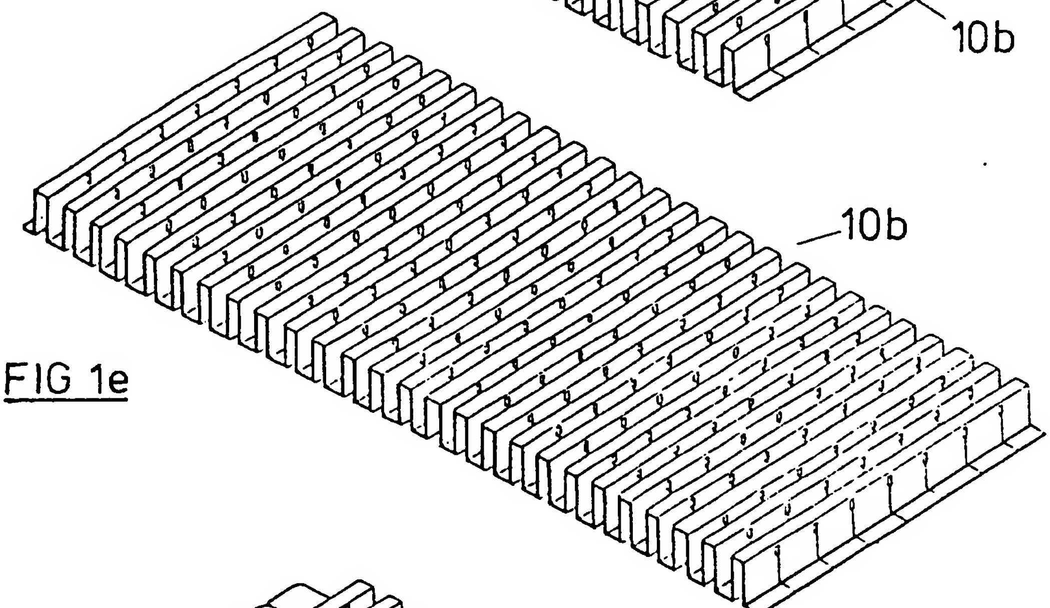


FIG 1e

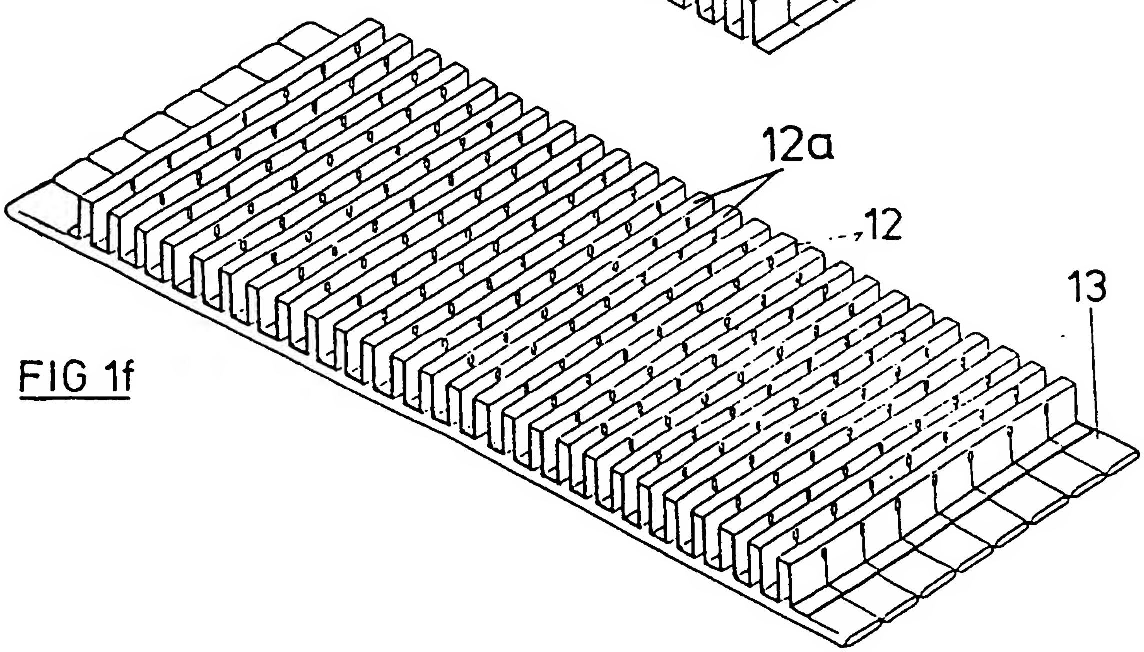


FIG 1f

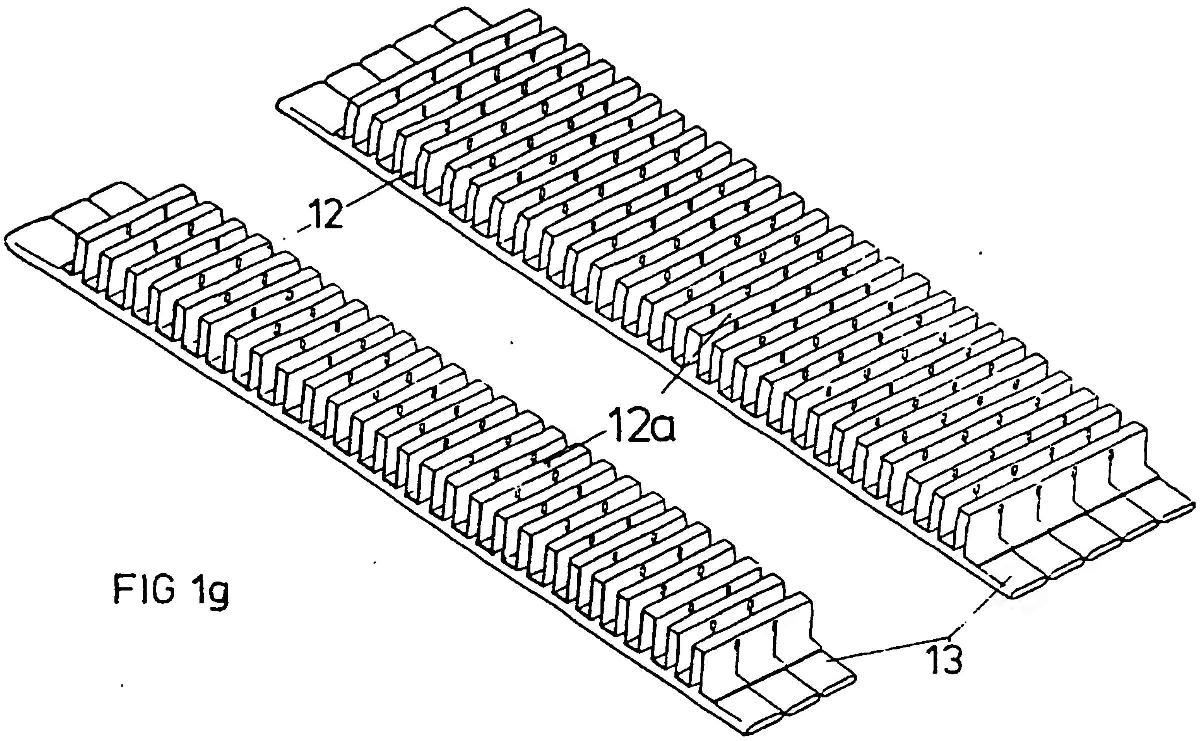


FIG 1g

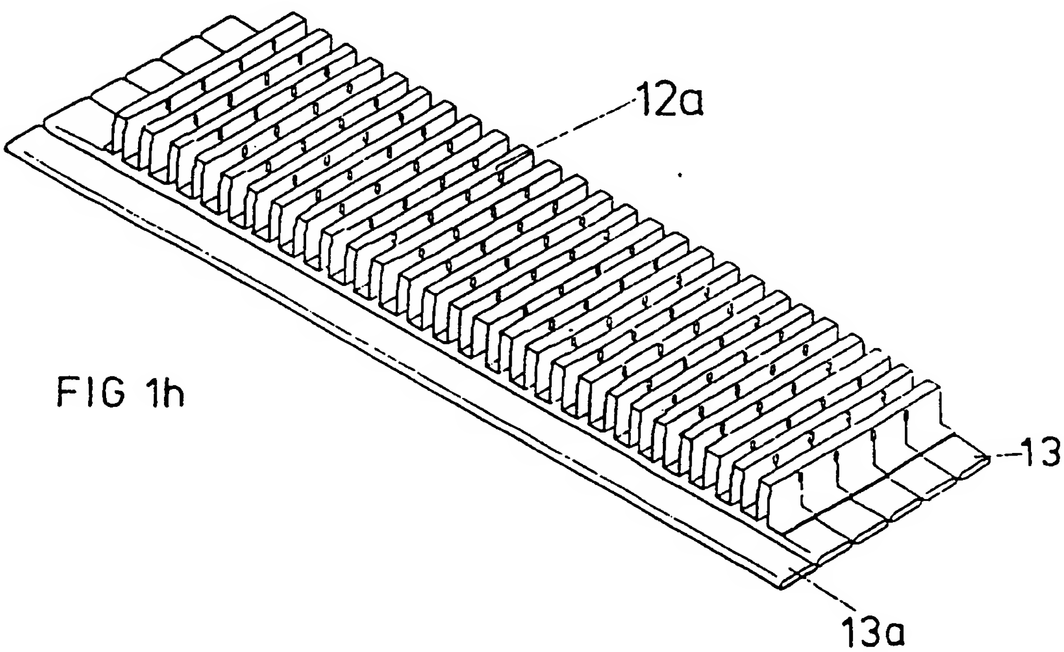


FIG 1h

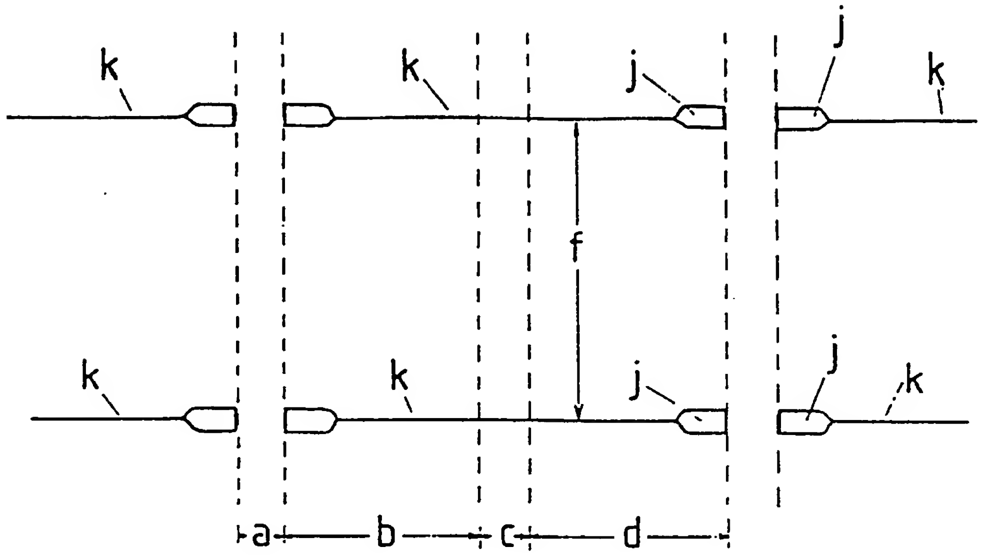
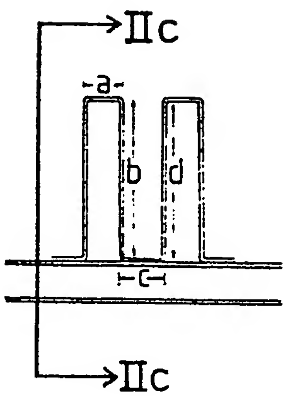


FIG 2a



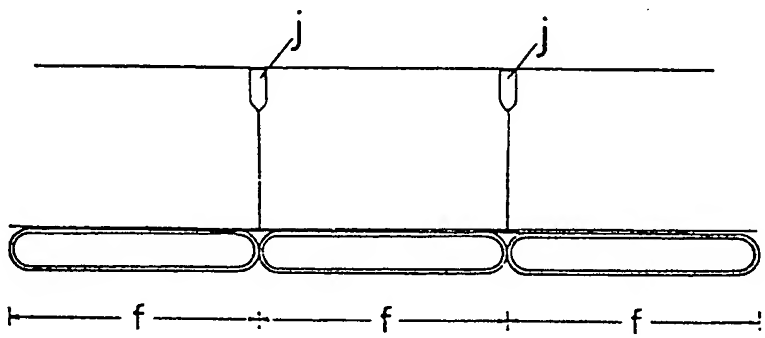


FIG 2b

FIG 2c

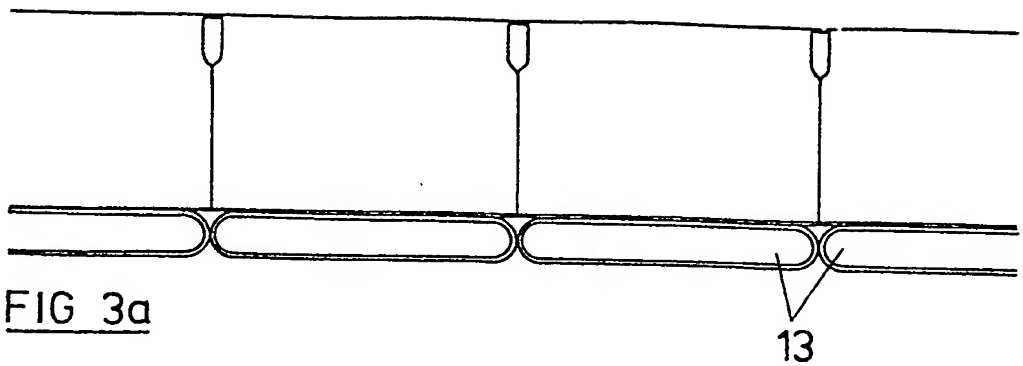


FIG 3a

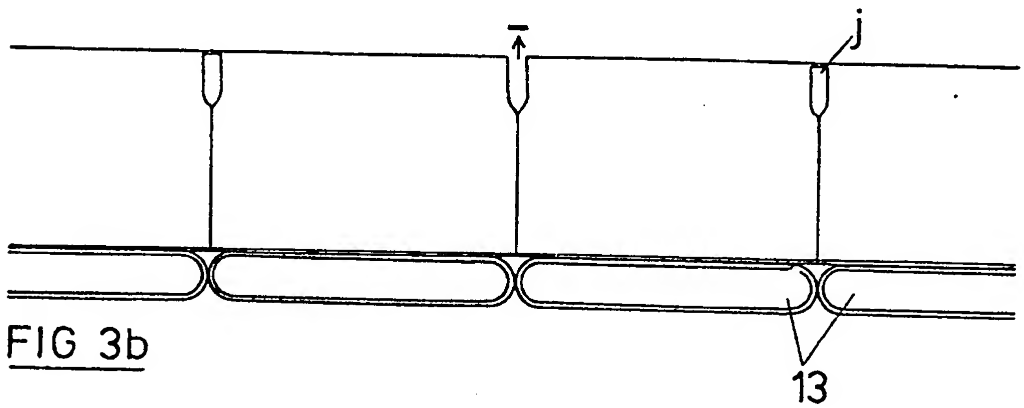


FIG 3b

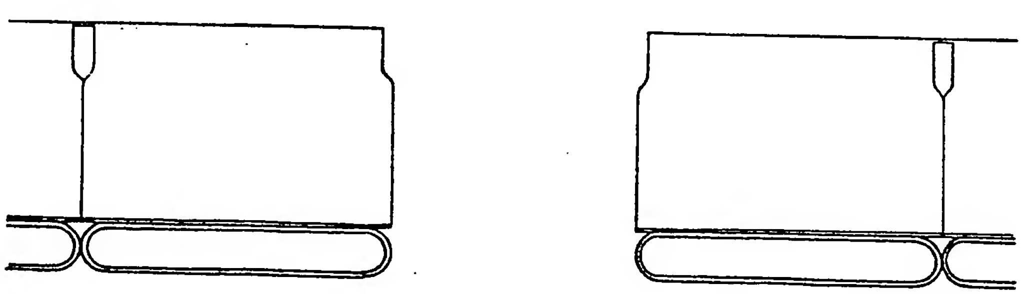


FIG 3c

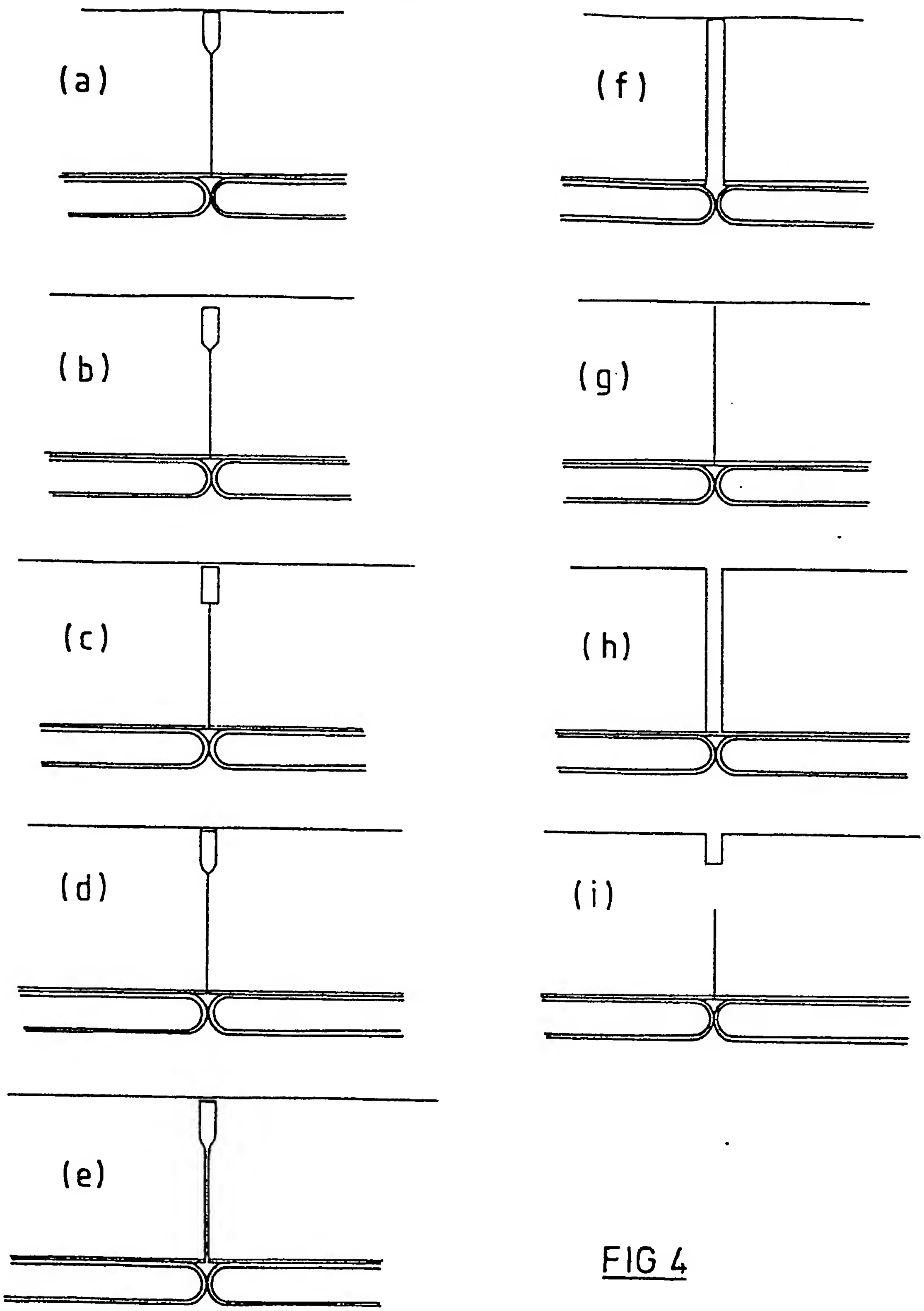


FIG 4

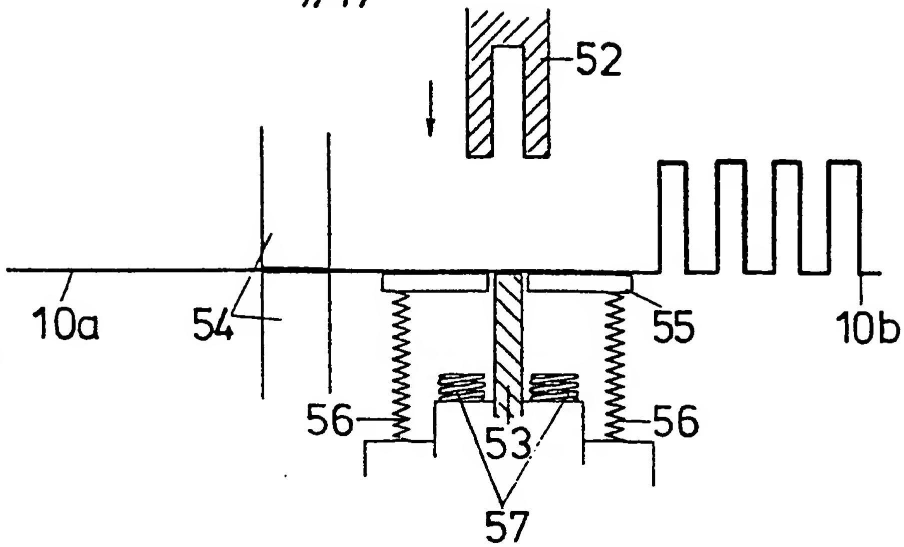


FIG 5a

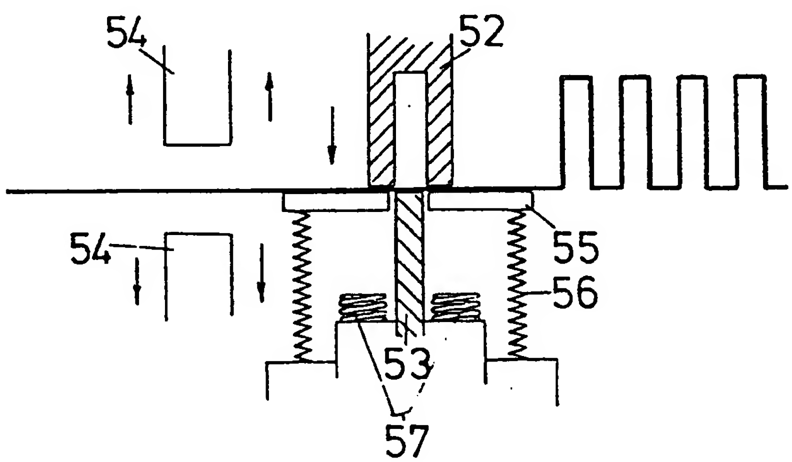


FIG 5b

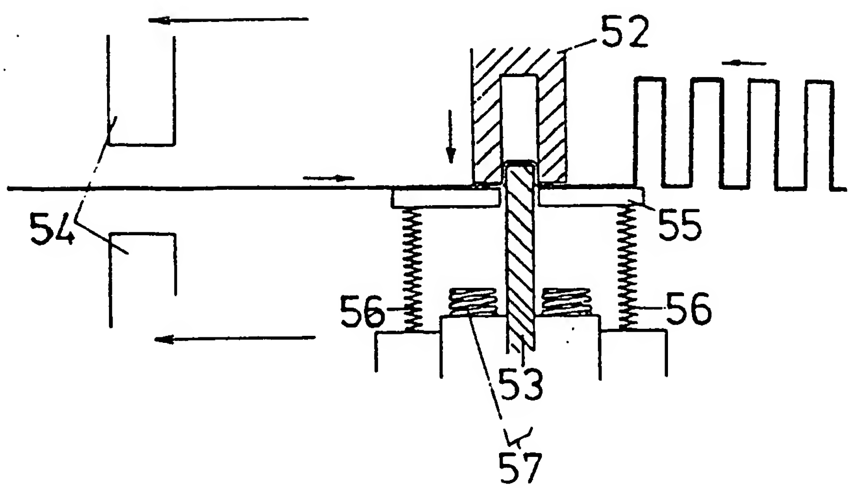


FIG 5c

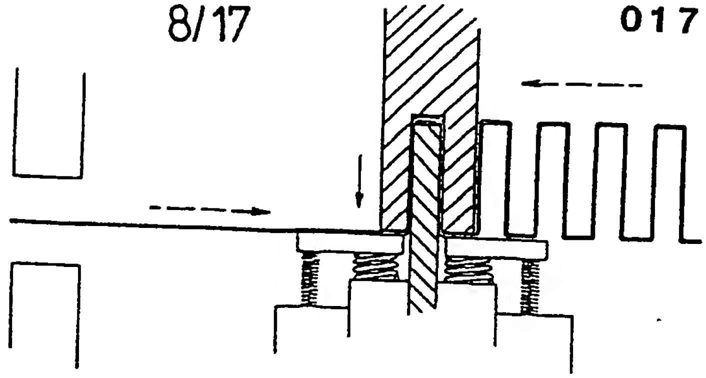


FIG 5d

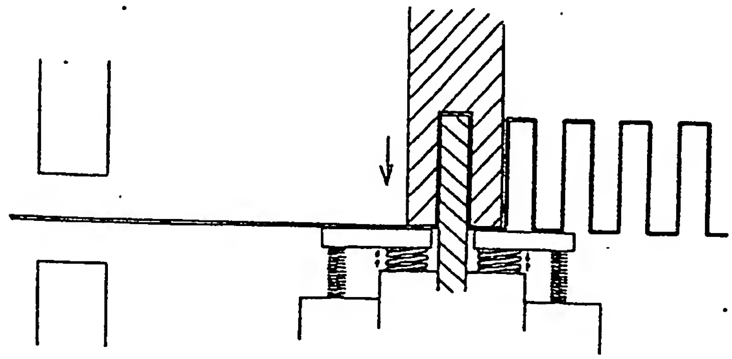


FIG 5e

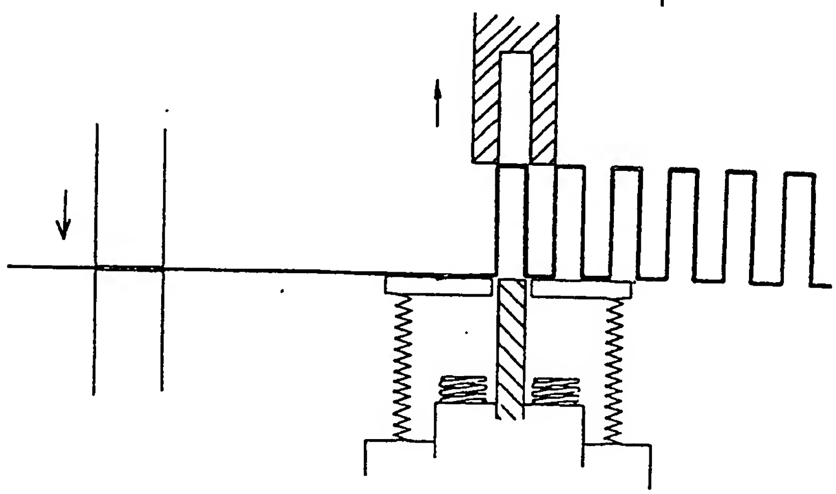


FIG 5f

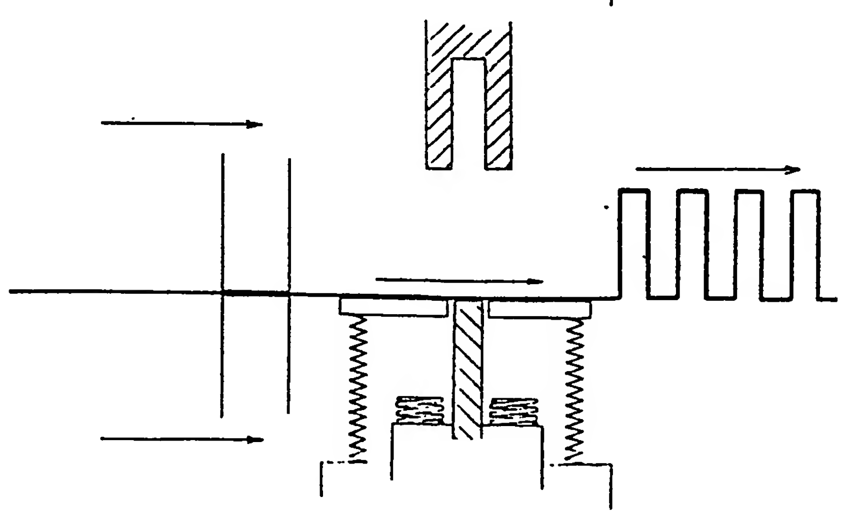


FIG 5g

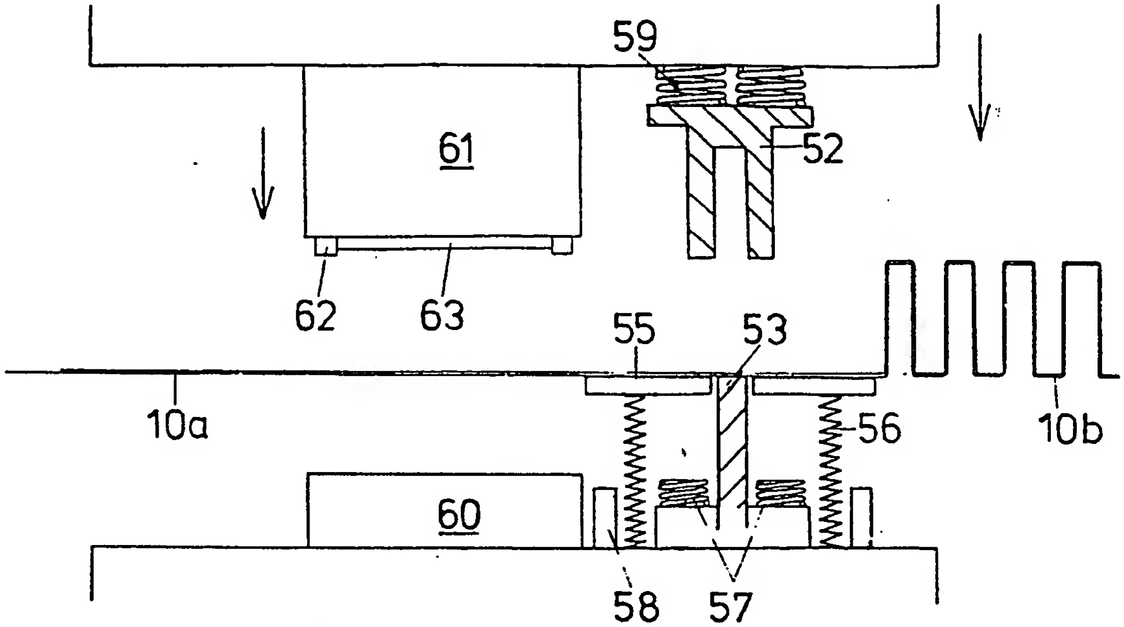


FIG 6a

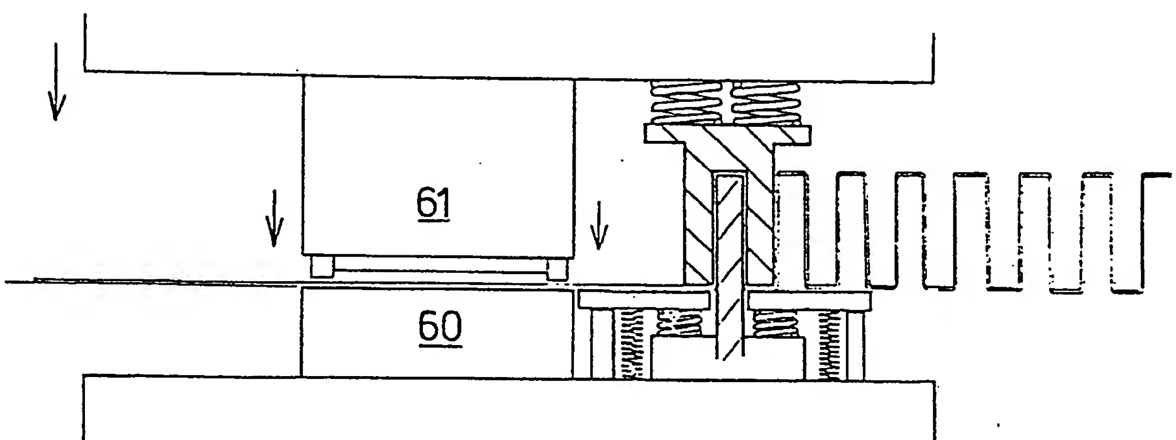


FIG 6b

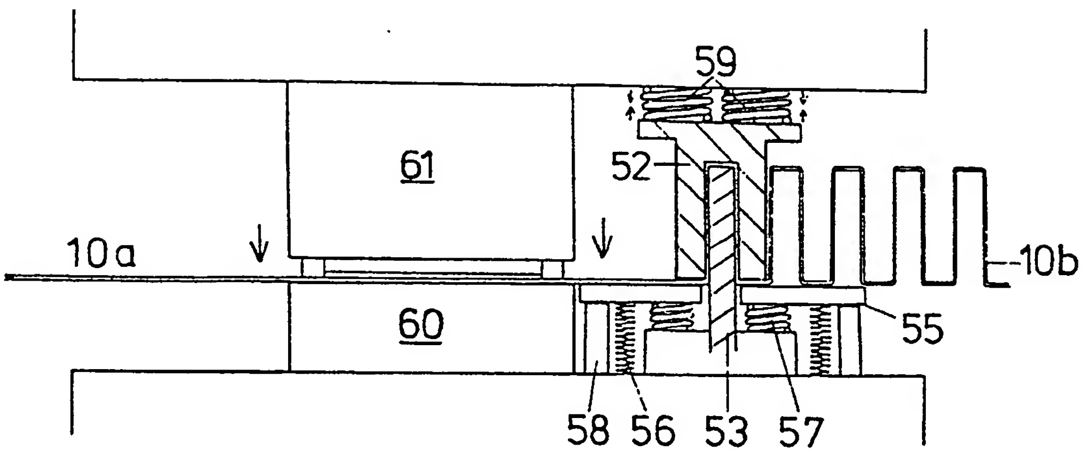


FIG 6c

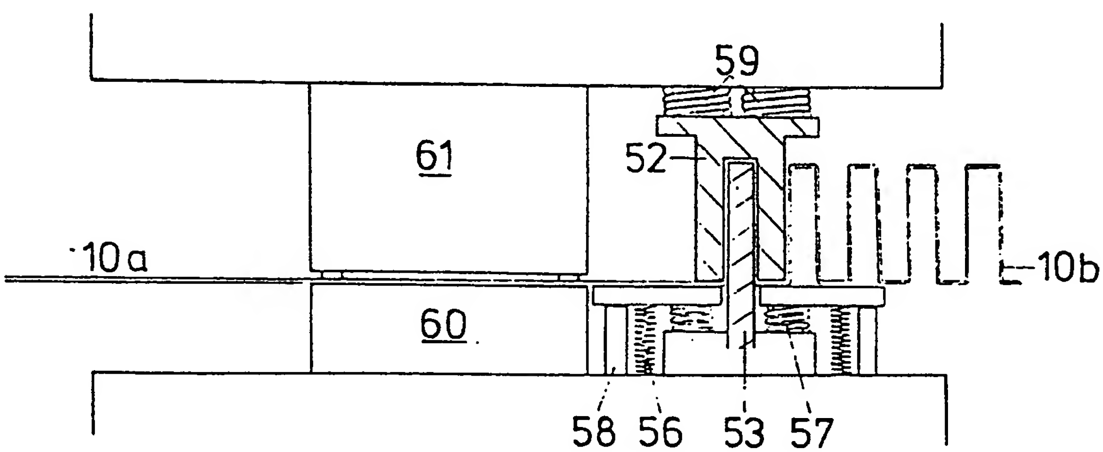
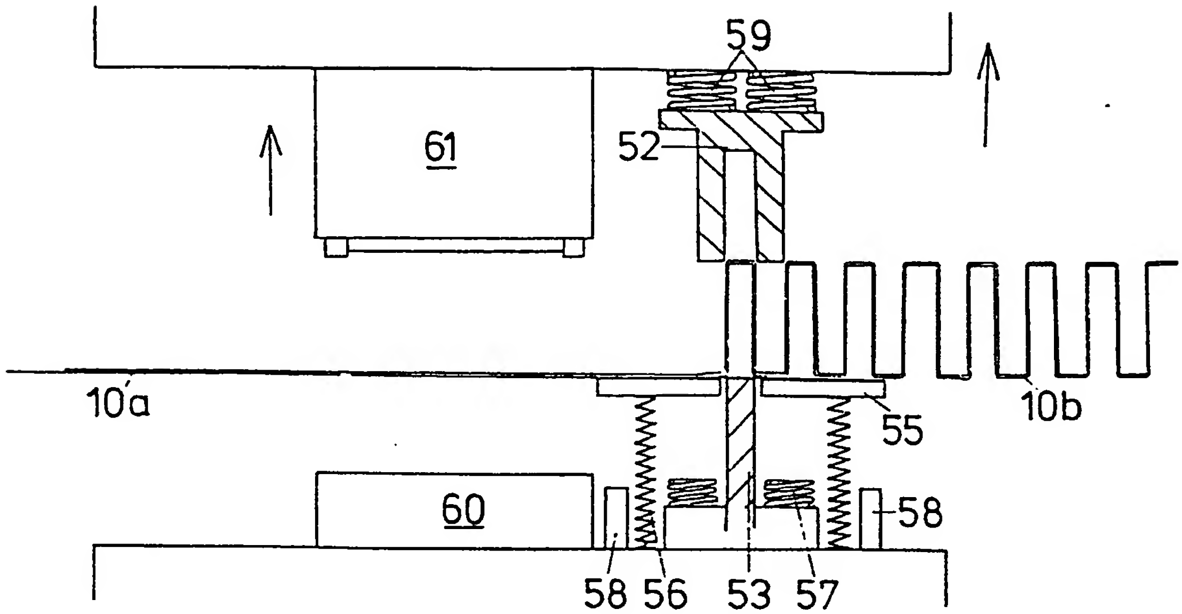


FIG 6d



59
61
52
10a
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10b
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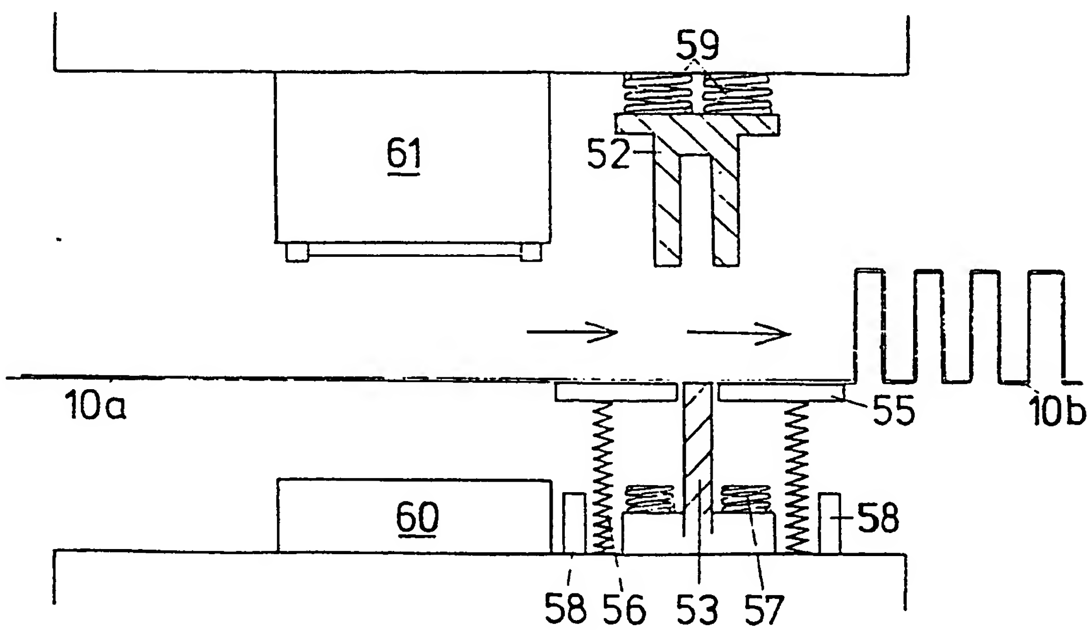
56
53
57

FIG 6e



59
61
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10b
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FIG 6f

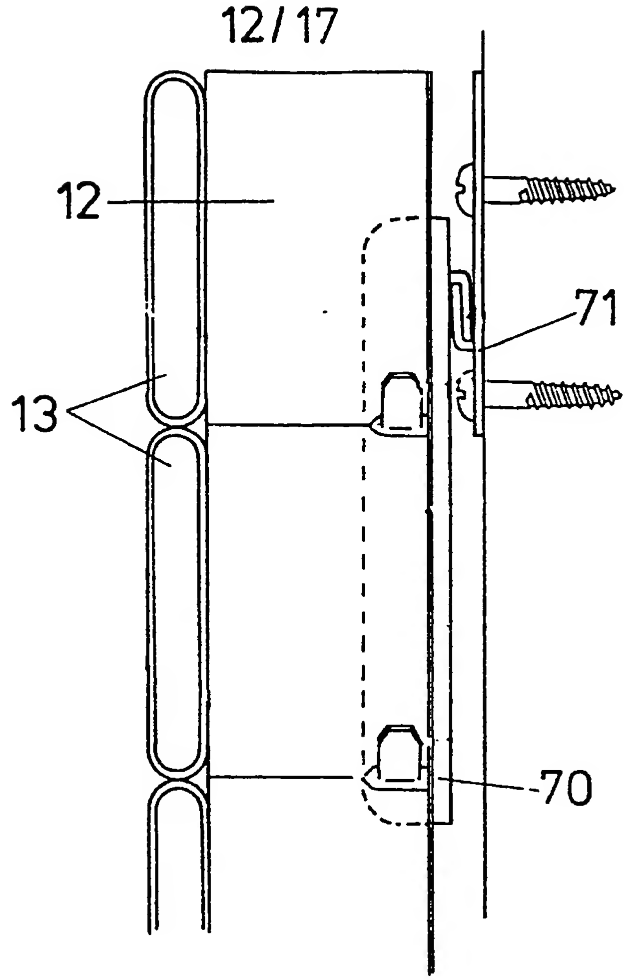


FIG 7a

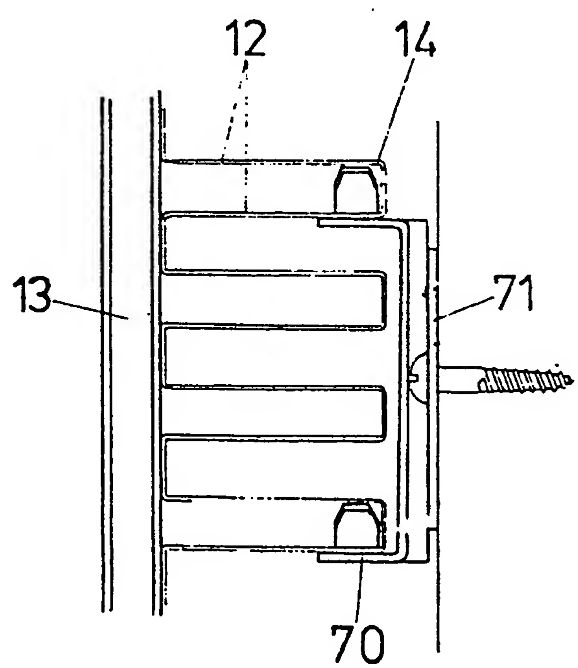


FIG 7b

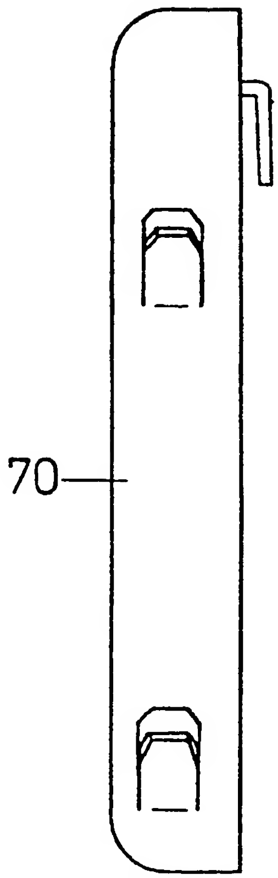


FIG 8a

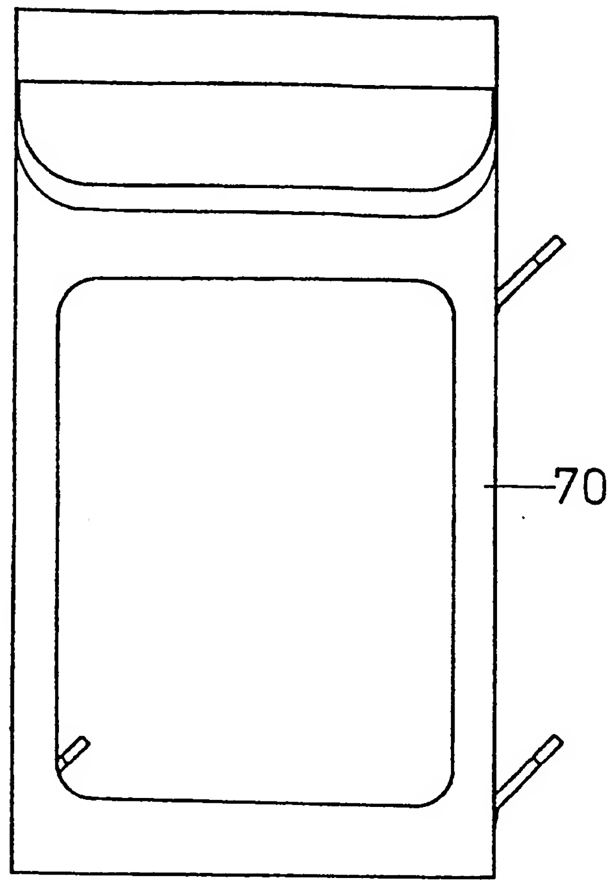


FIG 8b

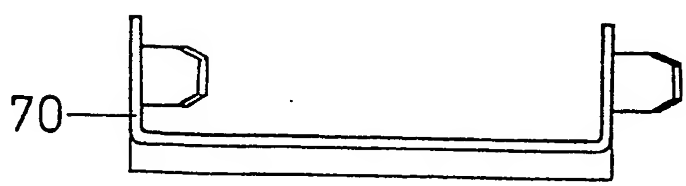


FIG 8c

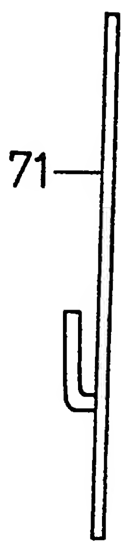


FIG 9a

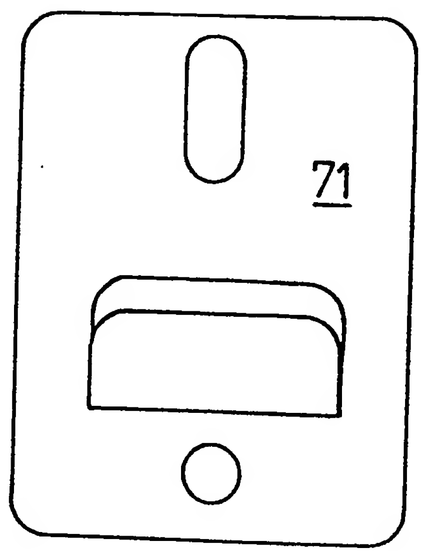


FIG 9b

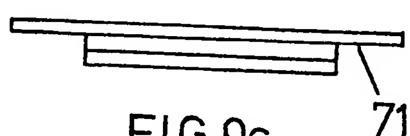


FIG 9c

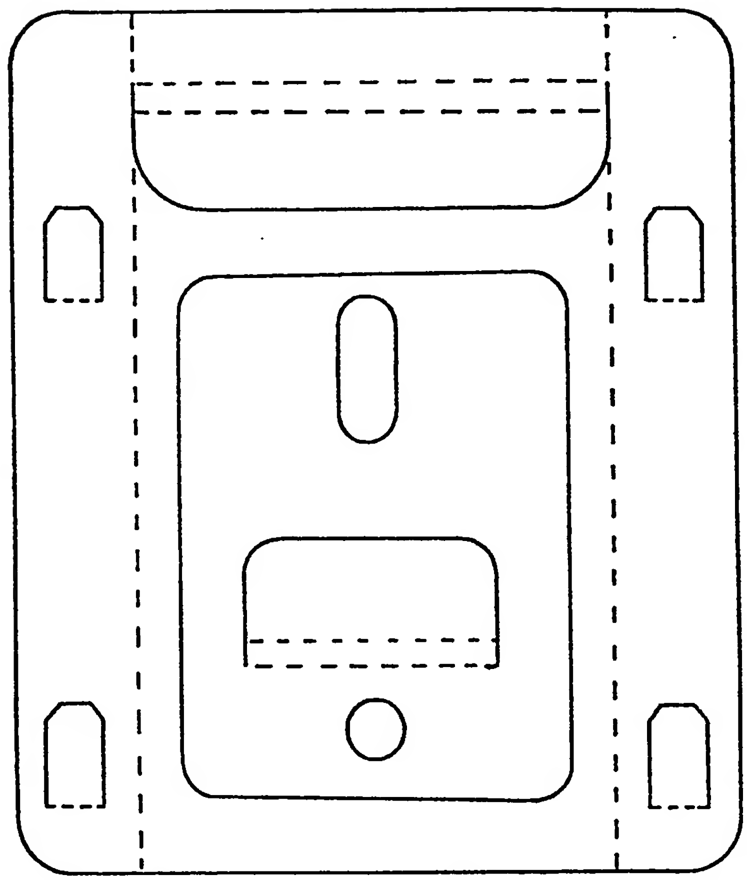


FIG 10

FIG 11

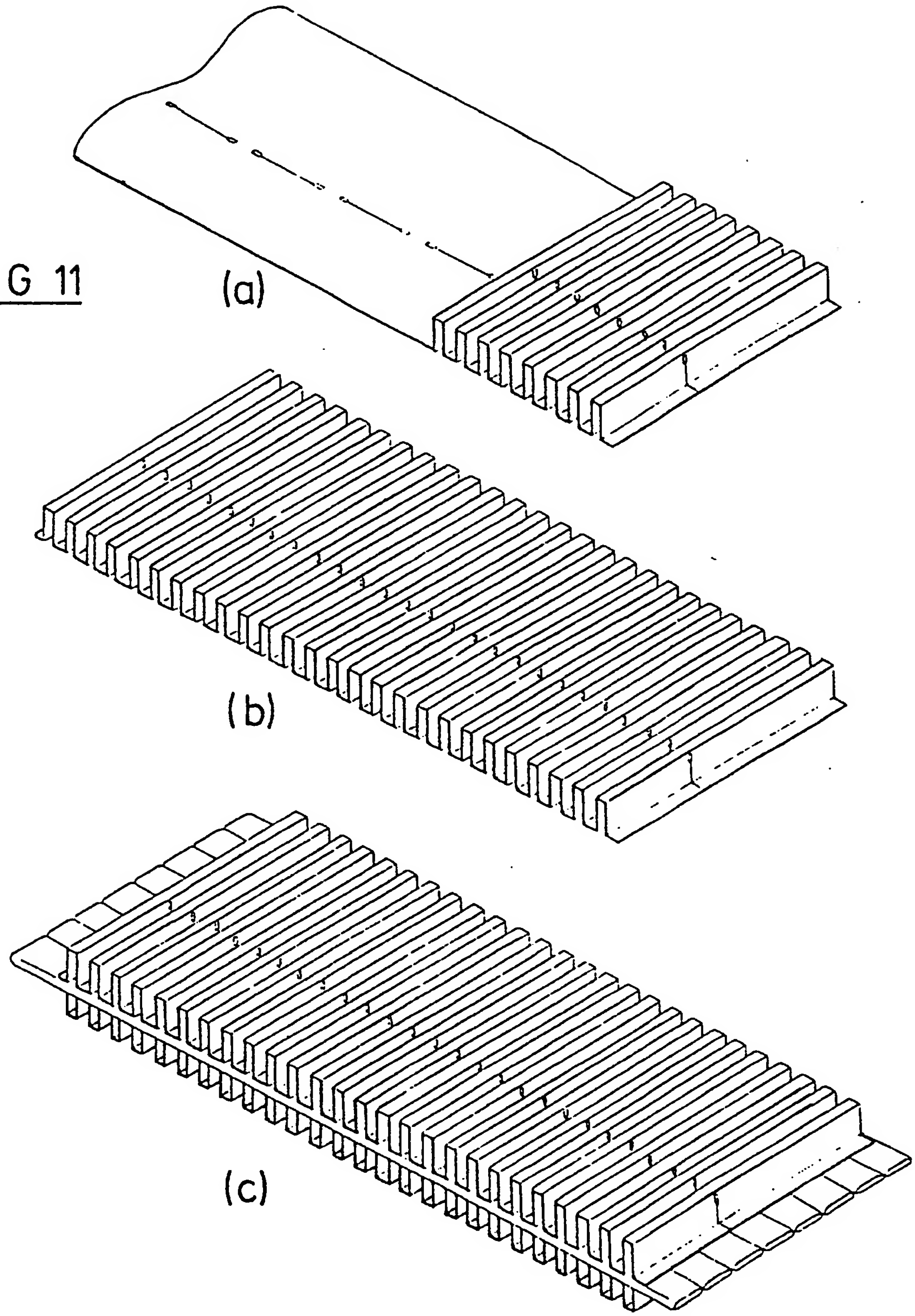
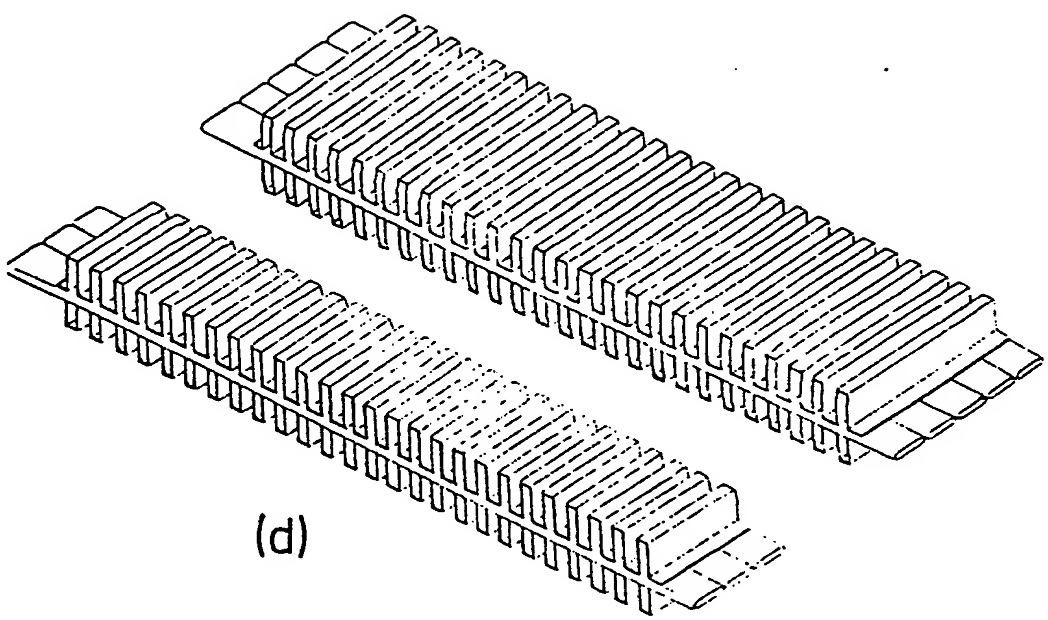


FIG 11



(d)